NASA/CR -96- 207478

7N-90-CR
067984

Final Report "Helium and Neon in Comets" (NAG 5-2631)

P2

Amount [redacted]

Period 07/01/94 - 06/30/96

Technical Officer Ronald Oliverson, Code 681.0

PI David Jewitt

Institution Institute for Astronomy, University of Hawaii

Overview

In this research, we focussed attention on two abundant noble gases, chosen to optimally constrain the ice formation temperature in comets. Noble gases have two special advantages for this work. First, they are chemically inactive and are thus immune to possible photochemical modification in the inner coma. Second, the trapping efficiency of the noble gases has been well measured in the laboratory. Helium was observed through its 584Å line and Neon through its 736Å line. Both lines are accessible only through EUVE.

Gas trapping experiments conducted in the laboratory have shown that even very volatile gases can be retained in porous ices formed at low temperature. These experiments also show that the trapping efficiency (determined by polarization and other forces acting on very small spatial scales in the interstices of amorphous ice samples) is a strong inverse function of the ice formation temperature. For example, ice samples grown by vapor deposition at 50 K (a plausible temperature for the likely formation region of the short-period comets) typically trap volatile gases up to about 10% of the water ice abundance. At 100 K, the trapped fraction falls to only 10^{-5}. These experiments motivated the above proposal: a determination of the abundance of very volatile gases (relative to water) might be used to measure the formation temperature of the cometary ices.

Research Results

Two comets were observed with EUVE in late 1994. Both comet Mueller and comet Borrelly are short-period comets having well established orbital elements and accurate ephemerides. Spectra of 40 ksec were taken of each. No evidence for emission lines from either Helium or Neon was detected. We calculated limits on the production rates of these atoms (relative to solar) assuming a standard isotropic outflow model, with a gas streaming speed of 1 km/s. The 3-sigma (99.7% confidence) limits (1/100,000 for He, 0.8 for Ne) are based on a conservative estimate of the noise in the EUVE spectra. They are also weakly dependant on the precise pointing and tracking of the EUVE field of view relative to the comet during the integrations. These limits are consistent with ice formation temperatures $T \geq 30$ K, as judged from the gas trapping experiments of Bar-Nun. For comparison, the solar abundances of these elements are He/O = 110, Ne/O = 1/16. Neither limit was as constraining as we had initially hoped, mainly because comets Mueller and Borrelly were intrinsically less active than anticipated. The limiting temperature is

compatible with independent assessments based on the high production rate of CO (for example) in comet Hale-Bopp, which give T ~ 50 K.

Personnel

This grant supported University of Hawaii graduate student Matthew Senay, whose PhD thesis (University of Hawaii 1997) is partially based on the results.